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Preparation and Structural Properties of CdS Thin Film by Chemical Bath Deposition

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ABSTRACT

Cadmium Sulphide (CdS) thin films have been prepared from the different concentrations of Cadmium Chloride and thiourea by chemical bath deposition. One of the most promising techniques for producing low cost Cadmium Sulphide (CdS) films for terrestrial photovoltaic applications. The annealing temperature was carried out at 500^0 C and seems to be important factors affecting the controlled growth rates of Cadmium Sulphide (CdS) films. The structural and characterization properties of CdS films were taken from X-ray diffraction (XRD), Scanning electron microscopy (SEM) and UV-Vis measurements to study their characterizations. X-ray diffractometry (XRD) were taken for measuring the crystallite size, d-spacing value and structure of the CdS film. The structural analysis showed that increase with thickness, crystalline and grain size increases where as strain and dislocation density decreases. Surface morphology and defects were studied by scanning electron microscopy (SEM).UV-VIS absorption studies revealed that CdS thin film have an optical band gap is optimal for photovoltaic applications. Cadmium Sulphide (CdS) is a suitable layer for developing newer photovoltaic devices.

Keywords: Cadmium Sulphide, scanning electron microscopy, photovoltaic devices.

1. INTRODUCTION

Excellent optical properties of CdS make it suitable for use in solar cells, photoconductor and diode laser. Being an n-type semiconductor material it has been observed that CdS is an excellent heterojunction solar cell partner of p-type narrow band gap semiconductor material like CdTe or $CuInSe_2$, where CdS layer is used as the window material[1-2]. In particular, heterojunction solar cells with a narrow band gap base and wide band gap window have been investigated in an attempt to develop efficient, stable and low-cost solar cells[3-4]. Polycrystalline CdS thin films have been prepared by diverse techniques including chemical bath deposition (CBD), electrodeposition, laser ablation, sputtering, vacuum evaporation etc. Among these various techniques[5-9], CBD presents several advantages over other techniques for film deposition.

In the present work, chemical bath deposition technique has been chosen for the deposition of CdS thin films as it is simple compared with other new and sophisticated techniques.

2. EXPERIMENTAL DETAILS

Cadmium sulphide thin films are deposited on glass substrates by chemical bath deposition method. Aqueous solutions of 0.02 M Cadmium chloride ($CdCl_2$), 0.05 M thiourea SC $(NH_2)_2$ and 5 ml ammonia were used to prepare CdS thin films. The solution is continuously stirred for several minutes and it becomes clear and homogeneous. Deionized water was added to make the solution up to 50 ml. The pH of the solution is maintained as 11 by using ammonia buffer solution. The temperature of the bath was maintained at 110°C, the clear yellow solution was obtained. The glass substrates were first cleaned in pure water, acetone, and double distilled water. The cleaned substrates were immersed vertically in the bath at 1hr.After deposition, the slides were removed from the chemical bath, and cleaned for several times with de-ionized water, then dried and annealed in 500^0C for 60 min.

A Rigaku x-ray diffractometer with copper radiation ($Cu_{K\alpha}$=1.5406Å) was used for the structural analysis of thin films. The surface morphology of CdS thin films was studied using a scanning electron microscope and optical properties were studied by UV-VIS spectrometer.

3. RESULTS AND DISCUSSION

3.1 X-Ray Diffraction analysis

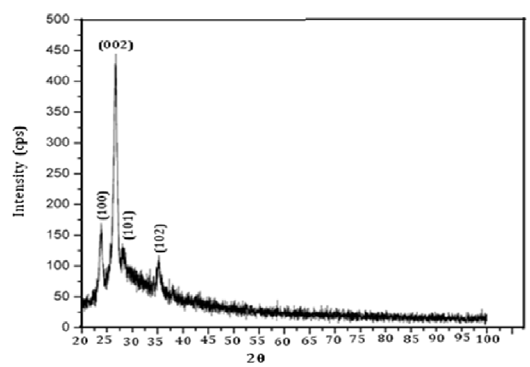

Fig.1 XRD pattern spectrum of the CdS film

The structural analysis of CdS thin films was carried out by using X-ray diffractometer. The X-ray diffraction patterns of the CdS thin films, grown on glass substrates are shown in Figure 1.The XRD analysis shows that the thin films are

Polycrystalline phase CdS with lattice parameters a = 4.079Å and c = 6.643Å which is almost in agreement with the standard data from JCPDS card No 80-0006. The planes are oriented in the direction (100), (002), (101) and (102). The films exhibit hexagonal crystal structure[10-12]. The highest intensity peak corresponds to (002) preferred orientation. The (002) peak is stronger than other peaks. In general, the preferential orientation of the films is along the (002) direction. The interplanar spacing for corresponding peaks is 3.5578Å, 3.337Å, 3.139Å respectively.

3.2 Morphological analysis

Fig. 2(a-c) shows the surface (SEM) image of annealed CdS film. CdS film composed of particles having size ranging from 250 to 300 nm. Particle size and crystallite size are different. Crystallite size is always smaller than particle size because a particle constitutes many crystallites.

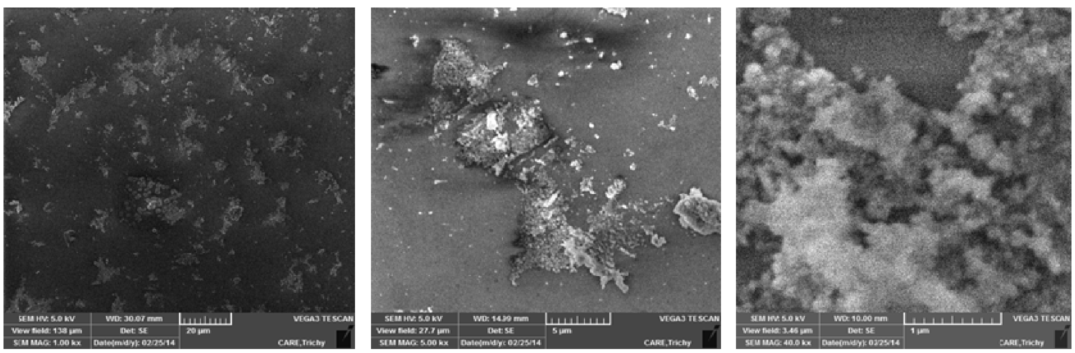

Figure 2: The SEM images of the CdS thin film (a) 20 µm (b) 5 µm (c) 1 µm

3.3 Optical Properties

Optical energy band gap (Eg) of synthesized films was calculated and plotted 'E_g' was attained from UV-vis analysis based on the following equation[13].

$$\alpha\, h\nu = (h\nu - Eg)^2 \qquad (2)$$

Where, α is the light absorption coefficient, h is the Planck constant and ν is the frequency. Extrapolation method in conjunction with the above equation produces Eg =2.28ev[14-15].

4. CONCLUSIONS

Using chemical bath deposition technique, CdS thin films have been coated at constant bath temperatures. The X-ray diffraction studies showed that the films are polycrystalline in nature with a mixture of hexagonal and cubic phases with hexagonal phase being predominant. The XRD analysis shows that the thin films are Polycrystalline phase CdS with lattice parameters a = 4.079Å and c = 6.643Å which is almost in agreement with the standard data from JCPDS card No 80-

0006. The interplanar spacing for corresponding peaks is 3.5578Å, 3.337Å, 3.139Å respectively obtained from calculation. The surface (SEM) image of annealed CdS film composed of particles having size ranging from 250 to 300 nm. Particle size and crystallite size are different. The optical transmittance for the as-deposited samples showed interference patterns. A direct band gap value was found to be equal to 2.28 eV for the films coated at 110°C. The high transmittance and low resistivity values obtained for the films coated using this technique is best suited for solar cell applications. From these results, it is evident that using this CBD technique, device quality CdS films can be successfully prepared and this technique can be considered as a desirable alternative to conventional technique for the production of CdS thin films as semiconducting layer for heterojunction solar cell applications.

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